Aerodynamic Aerosol Concentrators

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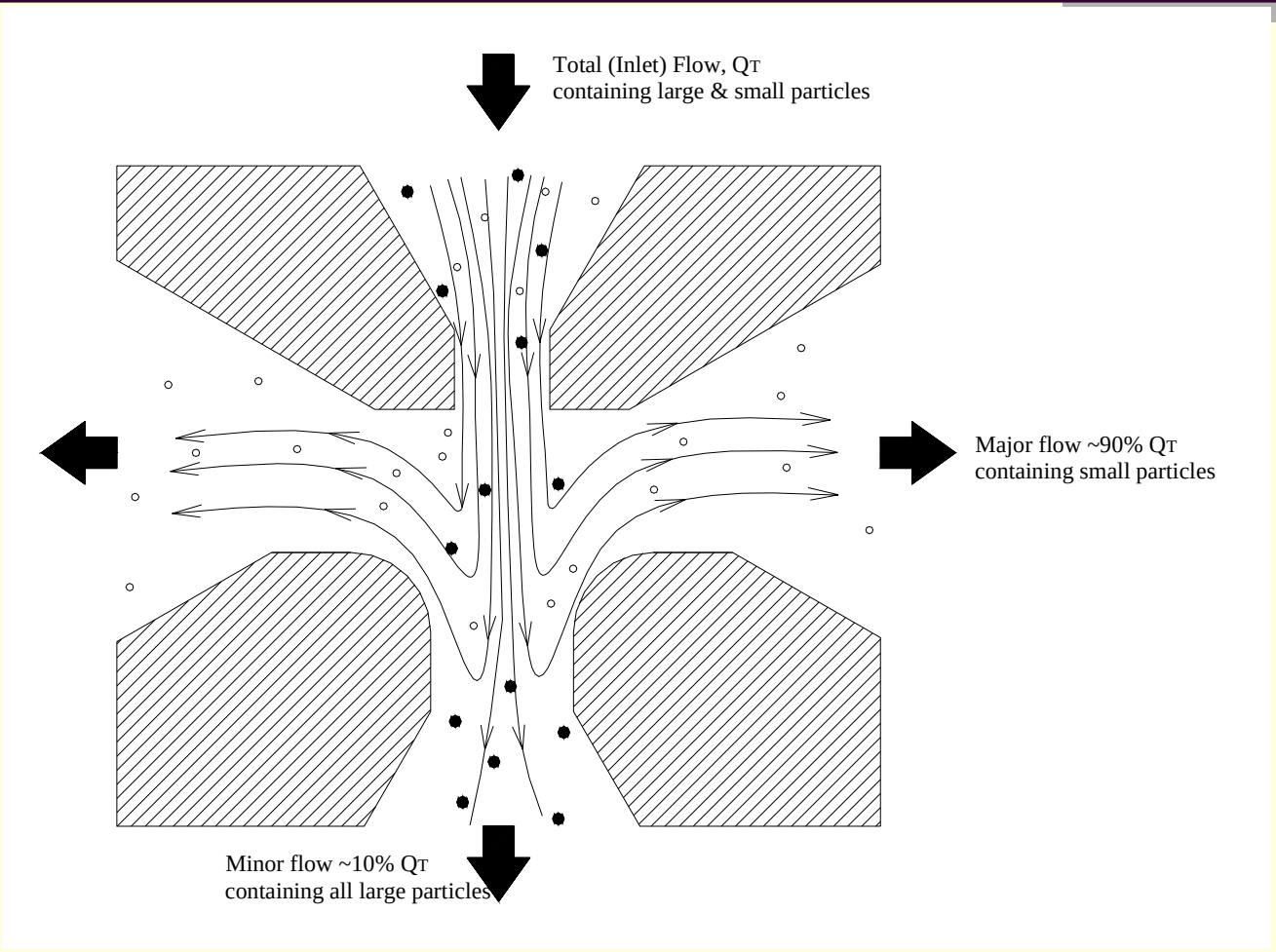
Overview

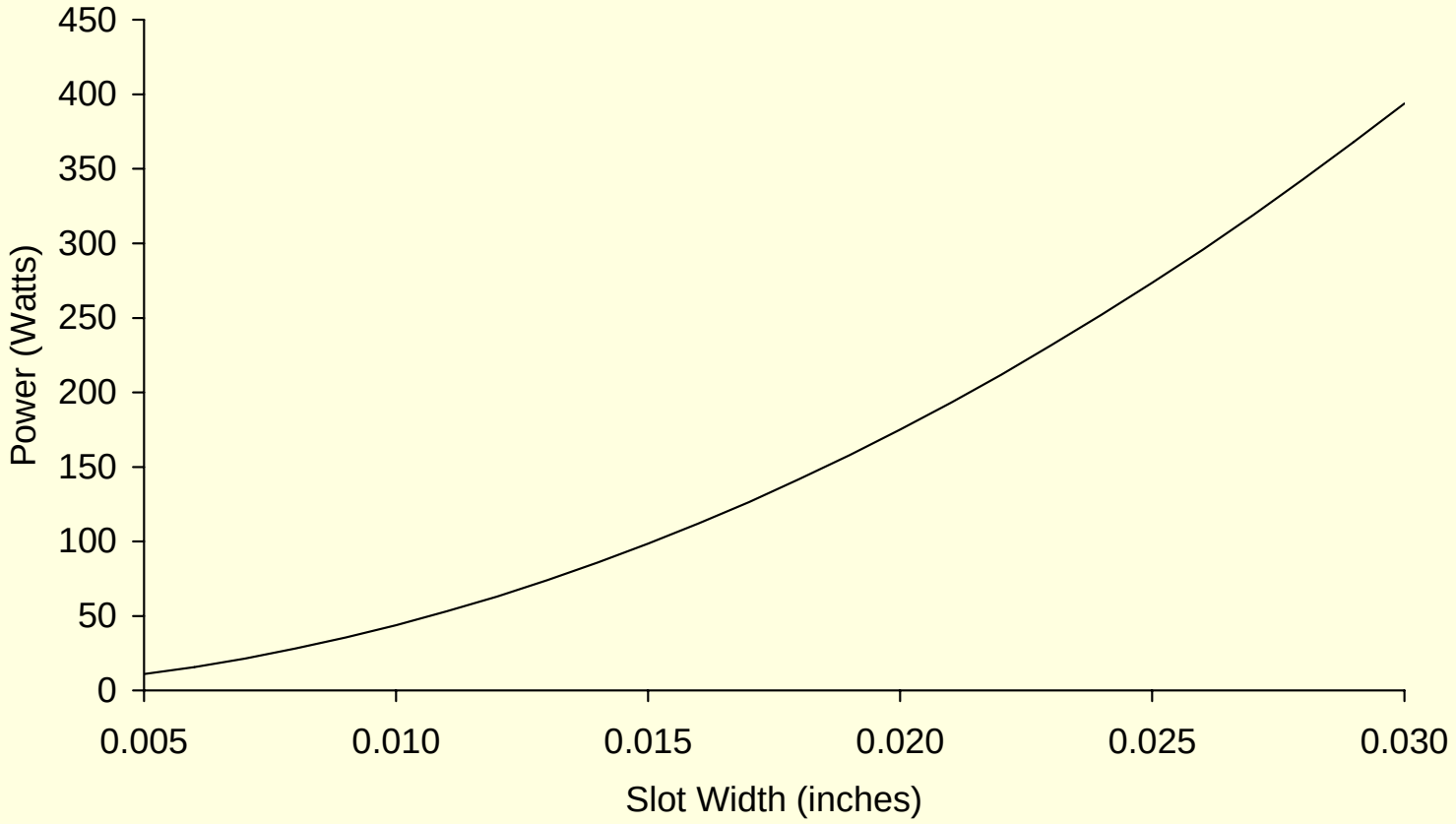
- **Detector Considerations**
  - Response threshold on the order of 10^4 particles.
  - Air handling system is a major power consumer in the detector system.
- **Goal:** Develop High-Throughput, Low-Power Bioaerosol Concentrators.
- **Slot-Nozzle Virtual Impactors**
  - Smaller nozzle dimensions reduce power consumed for fixed cutpoint and flow rate concentrator.
  - Slot nozzles are easier to manufacture for high through-put and resist fouling to a greater degree than round nozzle virtual impactors.
- **Prototype Devices**
  - LSVI and CSVI Units
  - Wall loss mechanisms
    - Misalignment of acceleration and receiver nozzle.
    - Receiver nozzle profile.
    - Acoustic resonance.
  - Experimental Data
- **Research Plans**

Concept of Virtual Impaction



Theoretical Power

(slot nozzle virtual impactor operating at
500 L/min and with 0.8 μm AD cutpoint)



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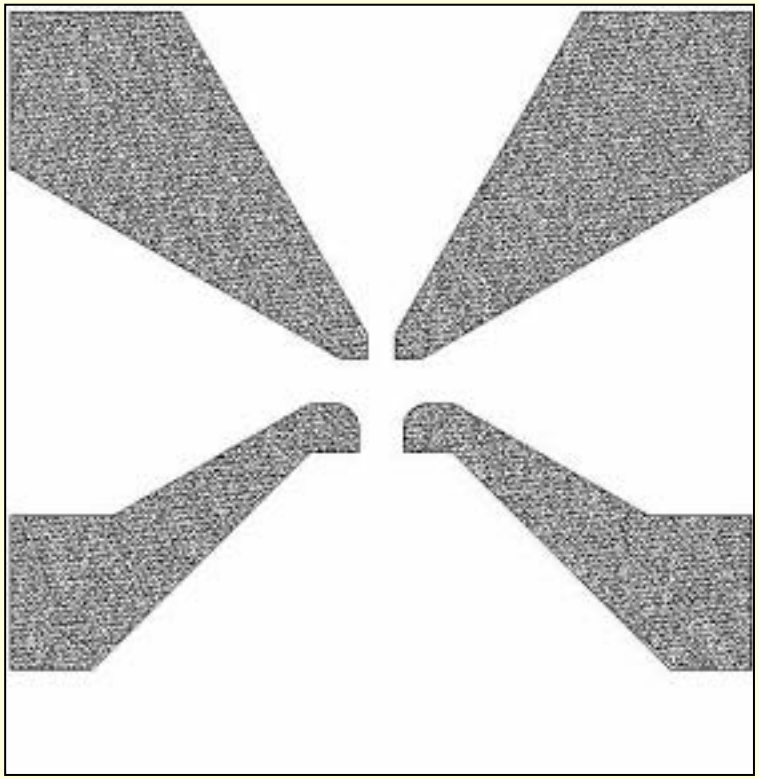
Nozzle Geometry of Current Slot Nozzle Prototypes



Acceleration nozzle width:
305 μm (0.012”)

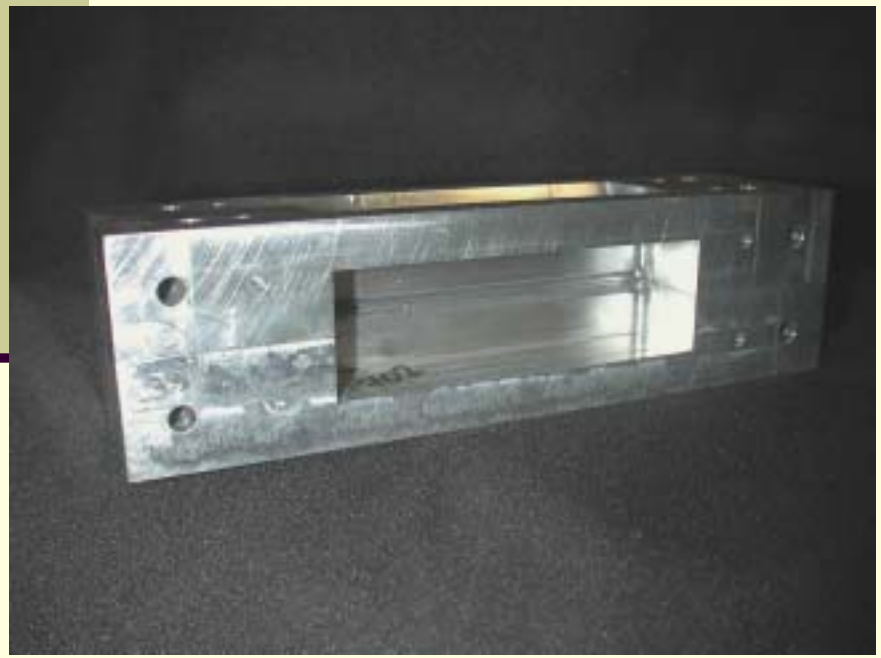
Receiver nozzle width:
457 μm (0.018”)

Slot length:
89 mm (3.500”)

Receiver nozzle taper:
Compound, 508 μm (0.020”) step, 60 degrees, full step

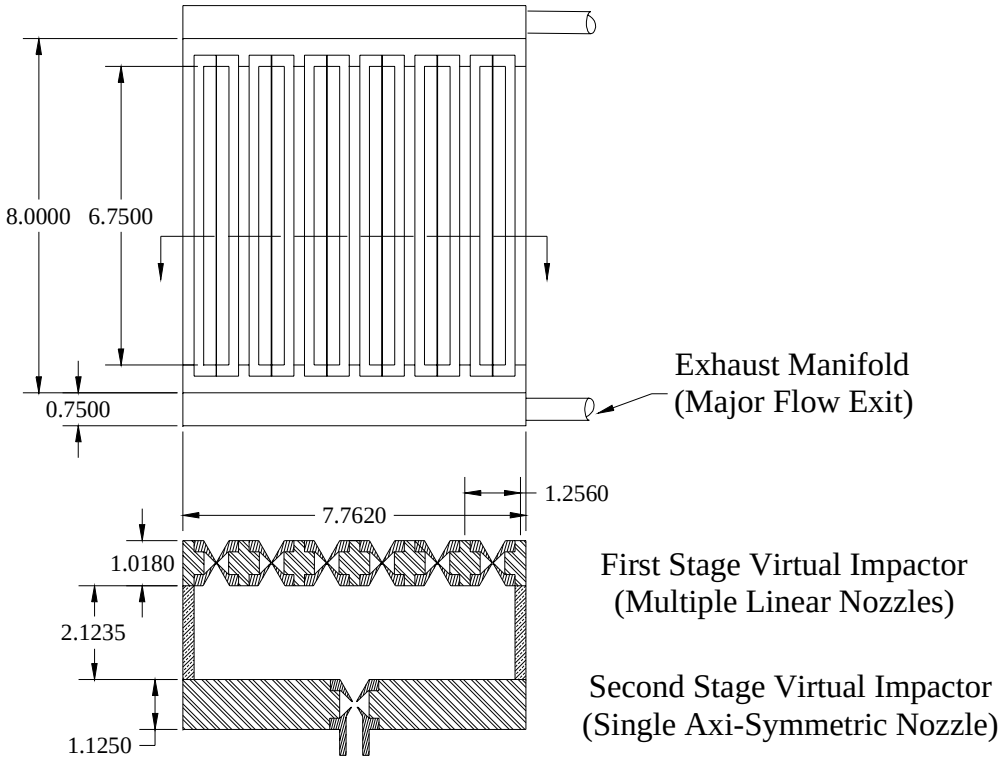
Prototype Slot Nozzle Virtual Impactors

- LSVI Prototype
- CSVI Prototype

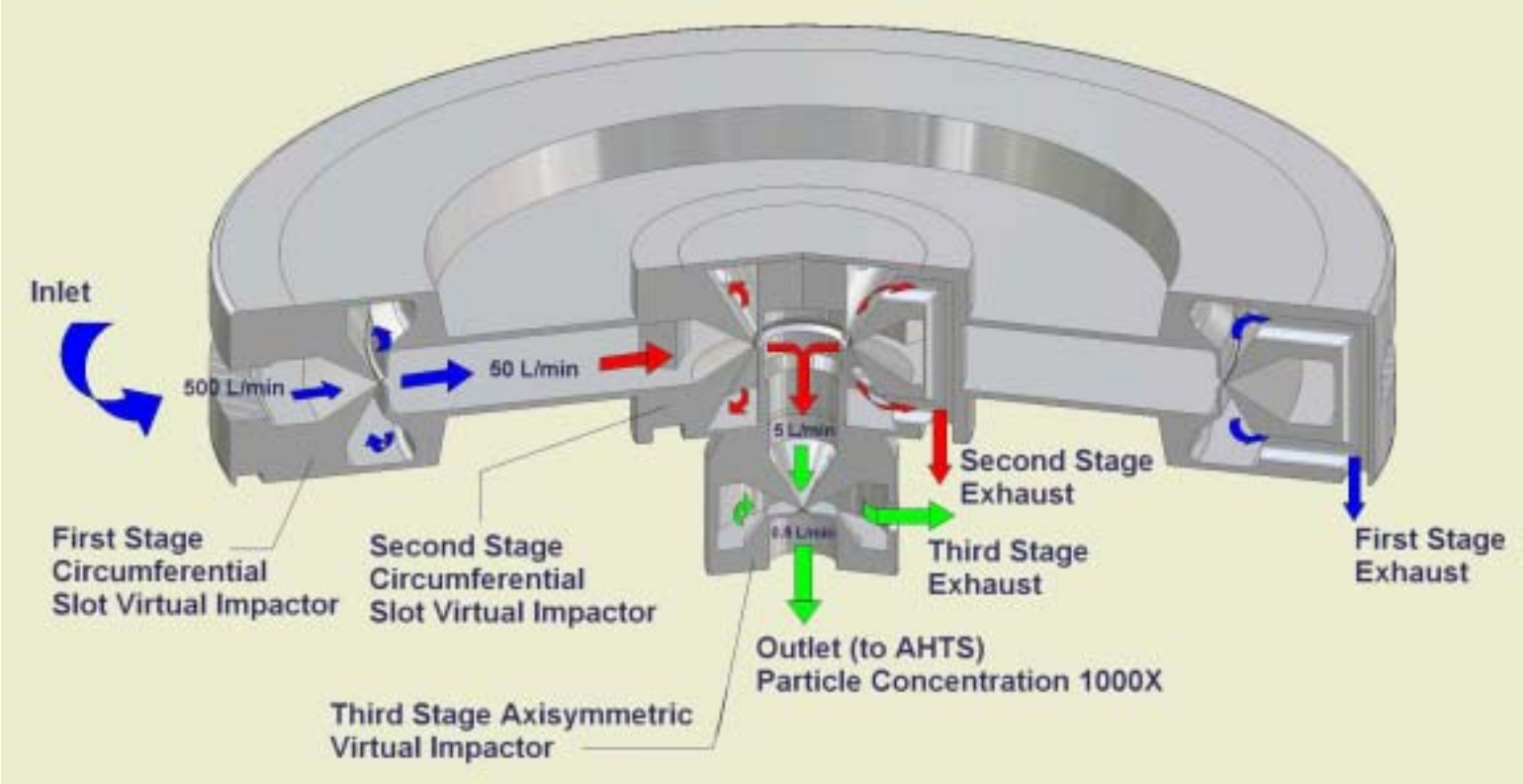


Multi-Stage LSVI Bioaerosol Concentrator

Plan and Cross-Section Views of
2 Stage Virtual Impactor



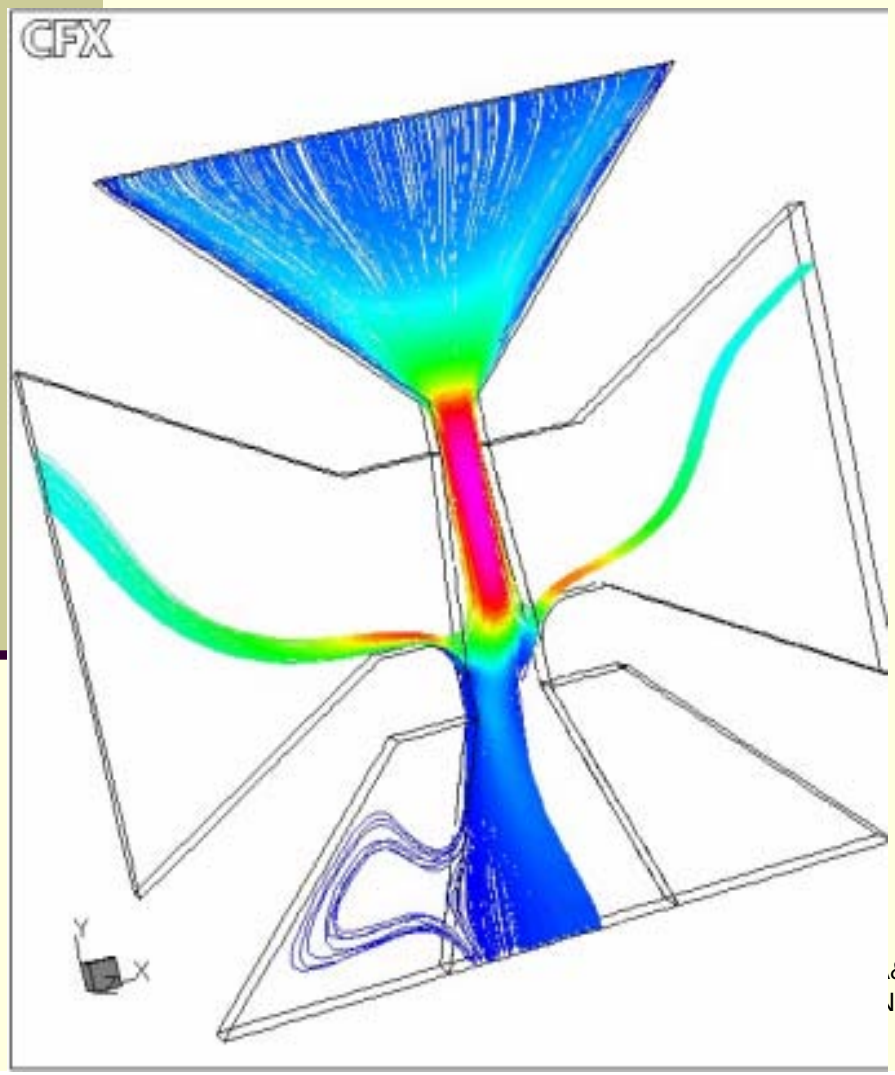
Multi-Stage CSVI Bioaerosol Concentrator

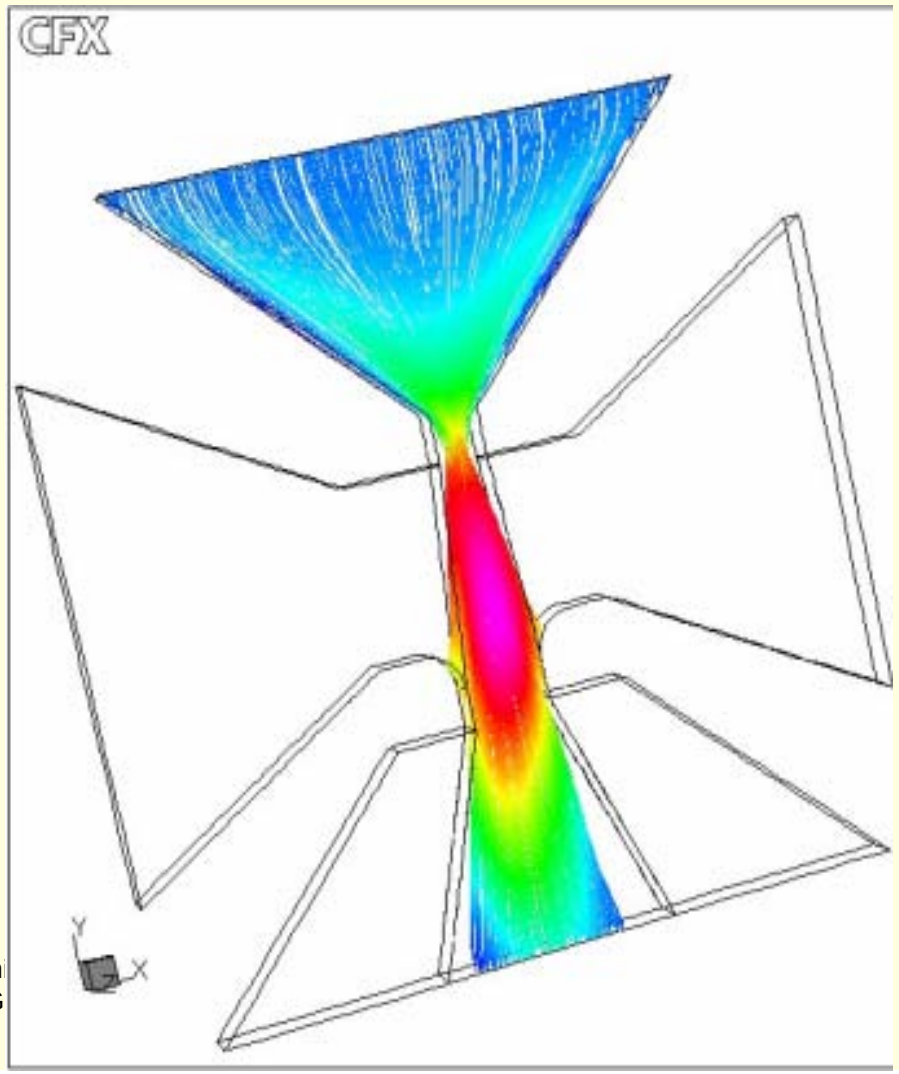


Comparison of Particle Deposition Evident on Receiver Nozzles Without (a) and With (b) Secondary Expansion

(a) (b)

Numerical Prediction of Particle Tracks (1.0 micron and 5.0 micron) with 0.002” Nozzle Misalignment

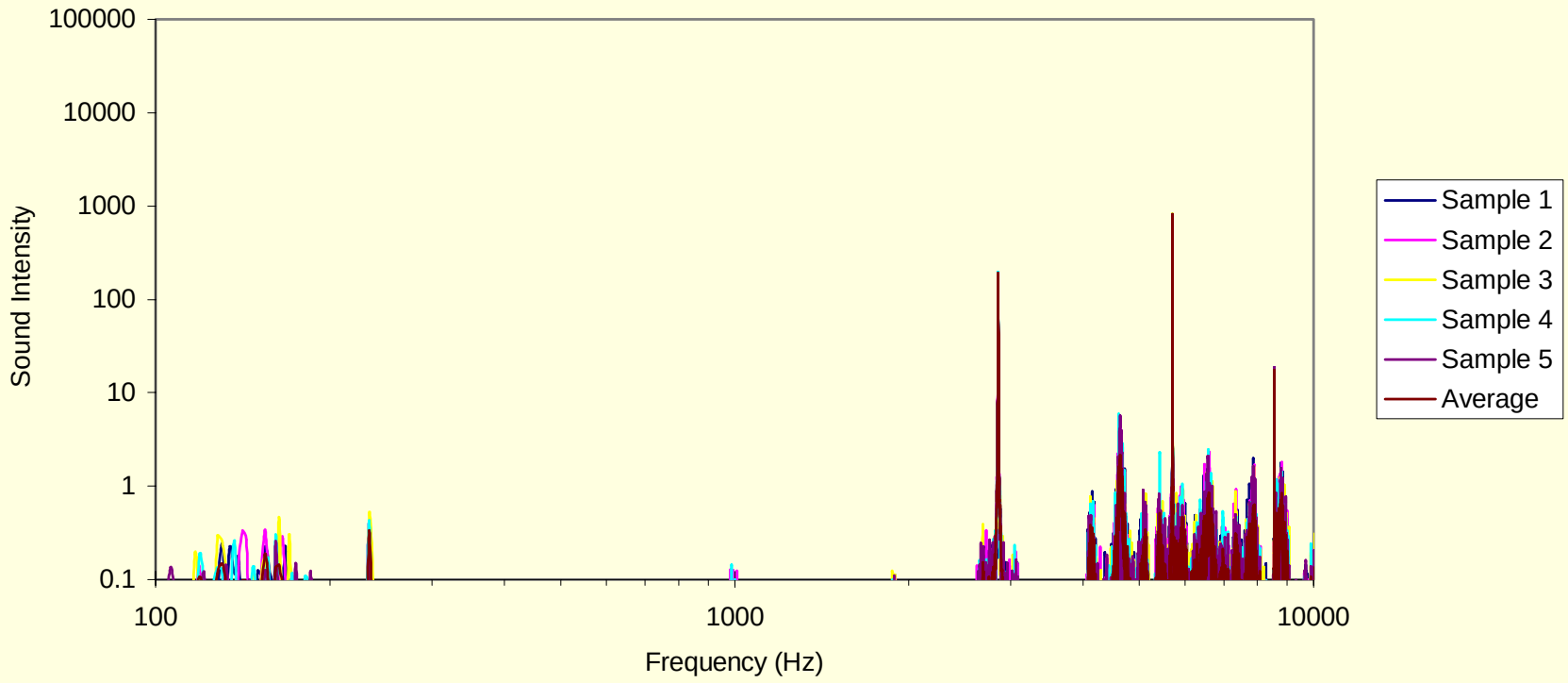




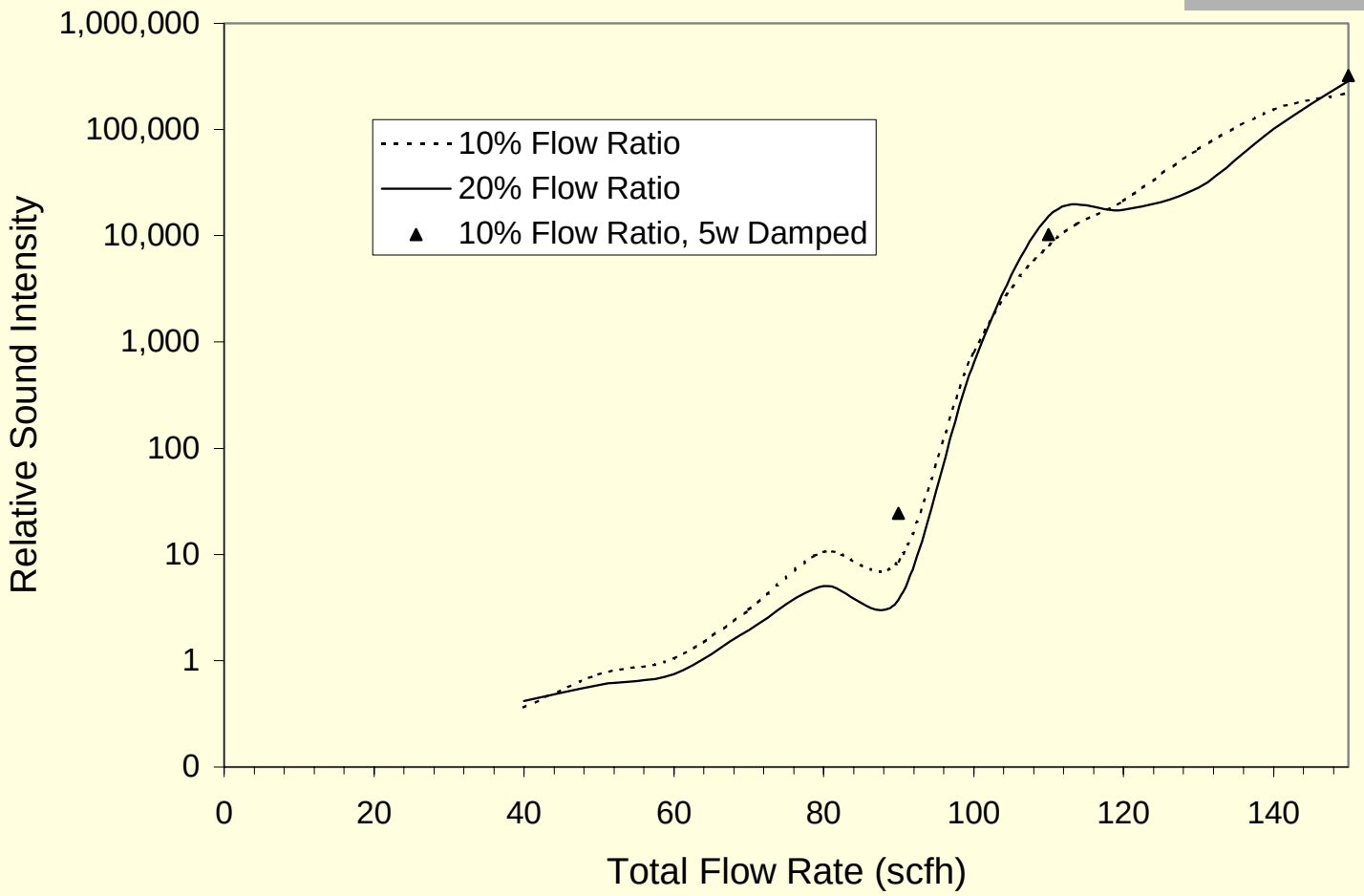
Sound Recordings of LSVI Open to Ambient Environment at Test Flow Rates

- LSVI 42 L/min 
- LSVI 47 L/min 
- LSVI 57 L/min 
- LSVI 66 L/min 

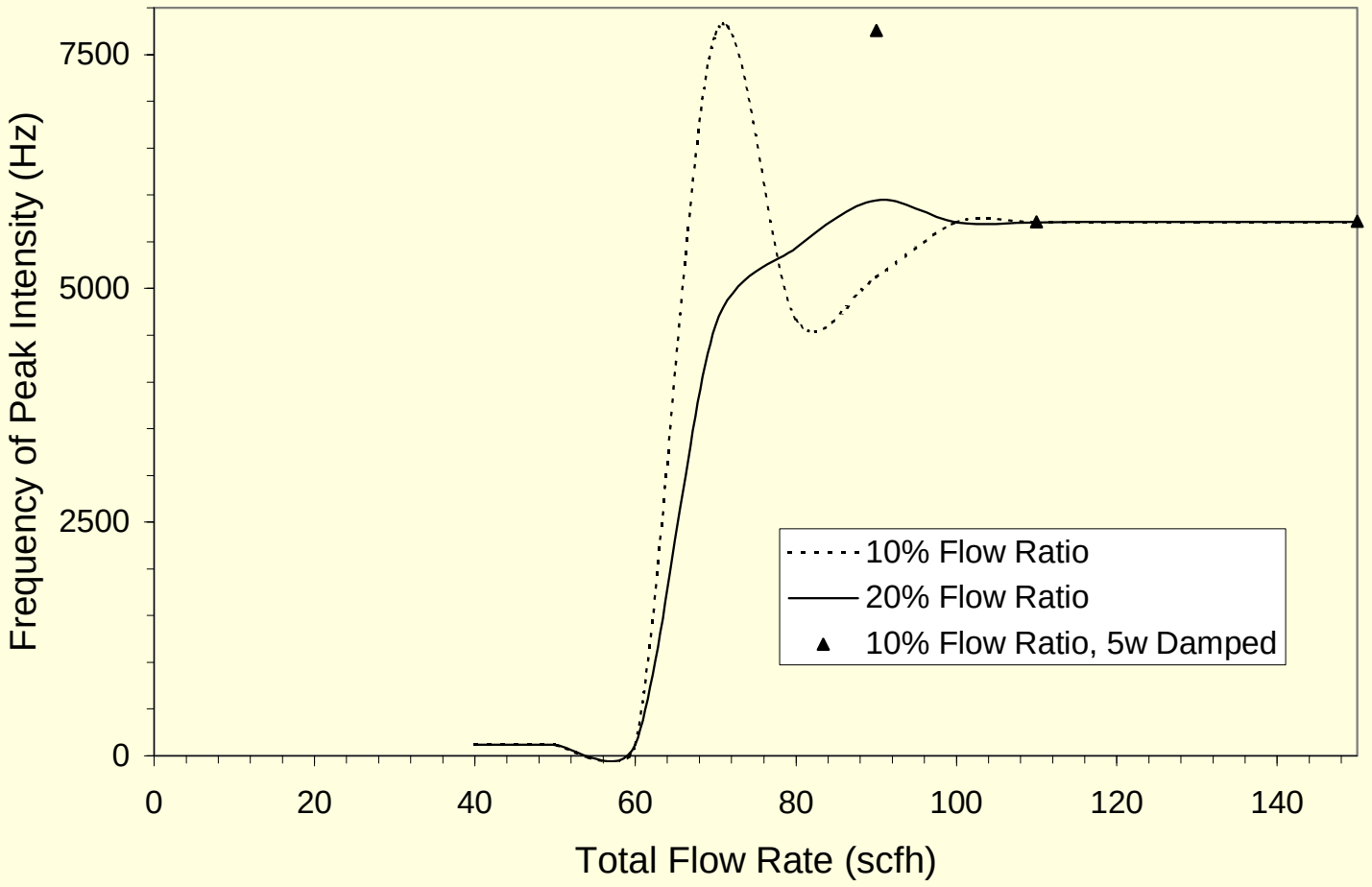
Sound Power Spectrum of LSVI at 47.2 L/min



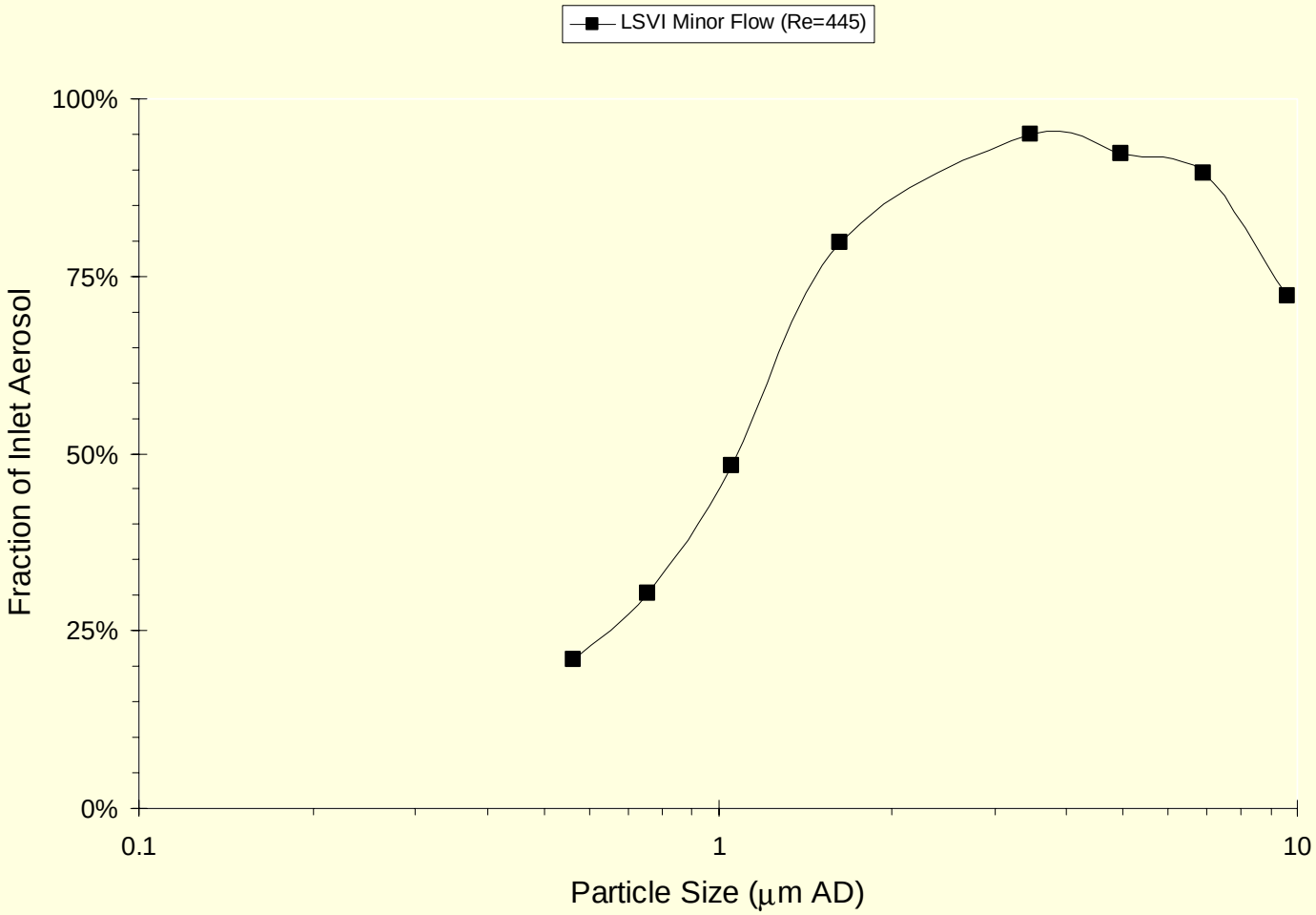
Peak Sound Intensity of LSVI Unit



Frequency of Peak Sound Component



Collection Efficiency of LSVI Minor Flow



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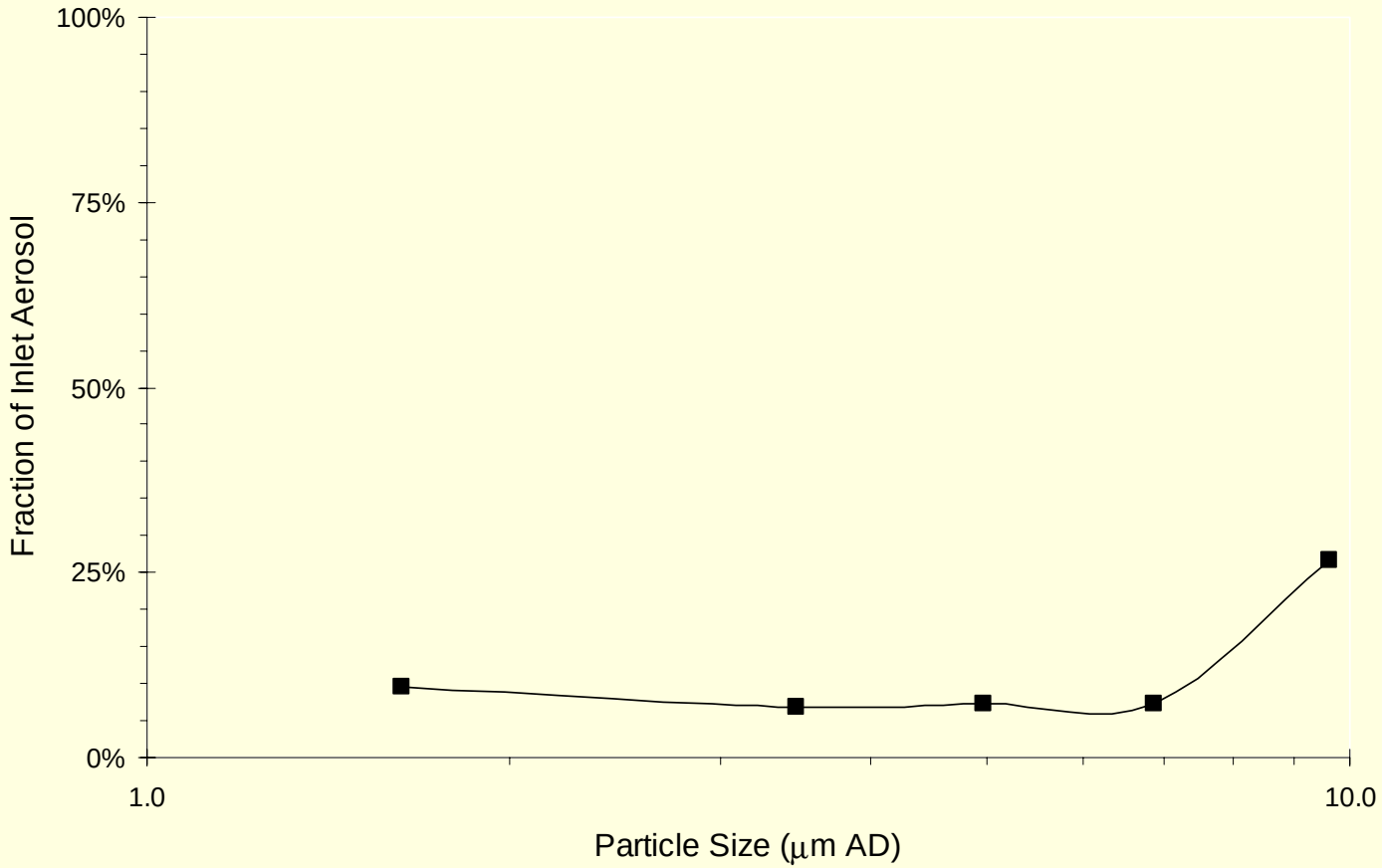
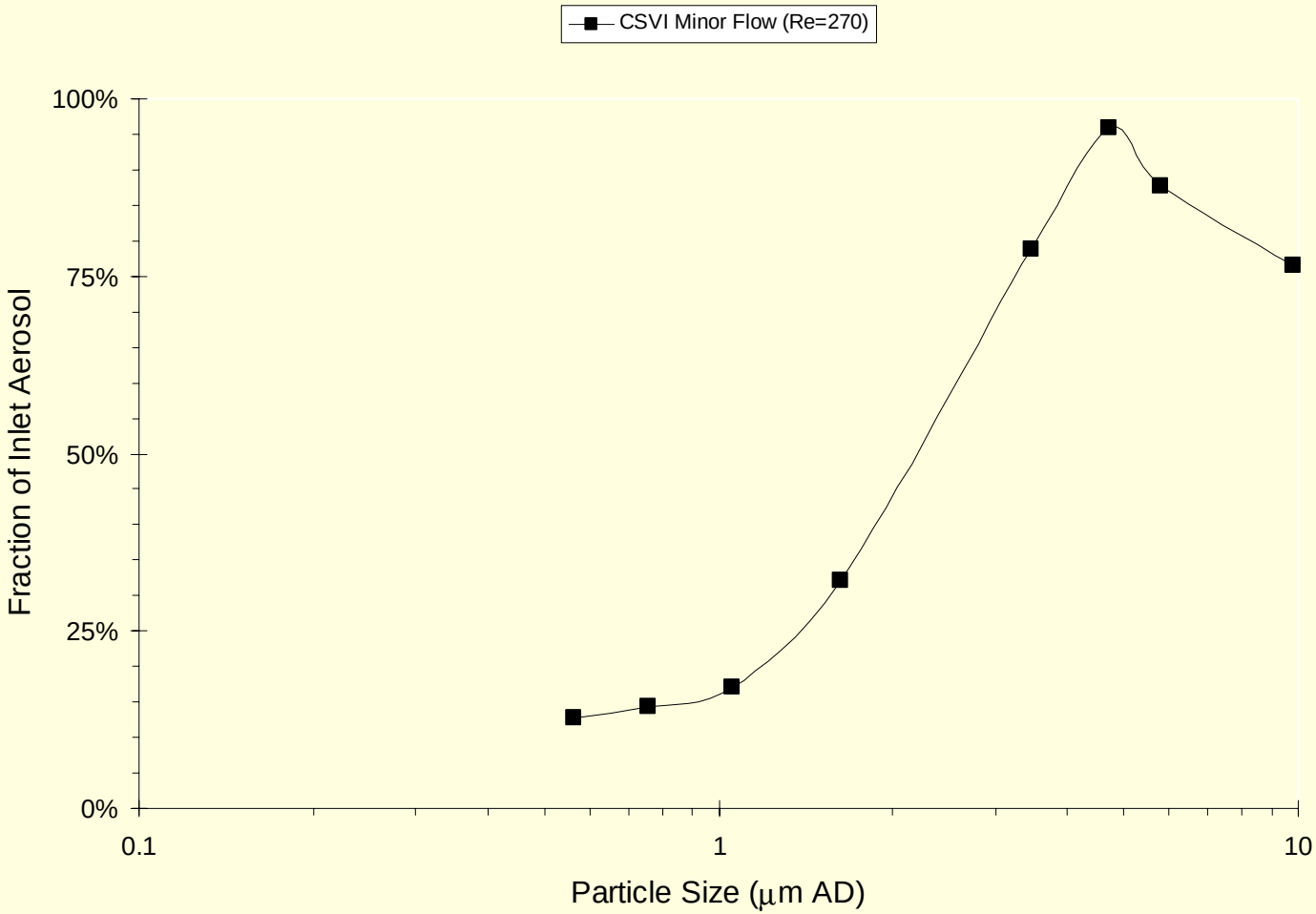
Wall Losses on Critical Zone of LSVI



Collection Efficiency of CSVI Minor Flow



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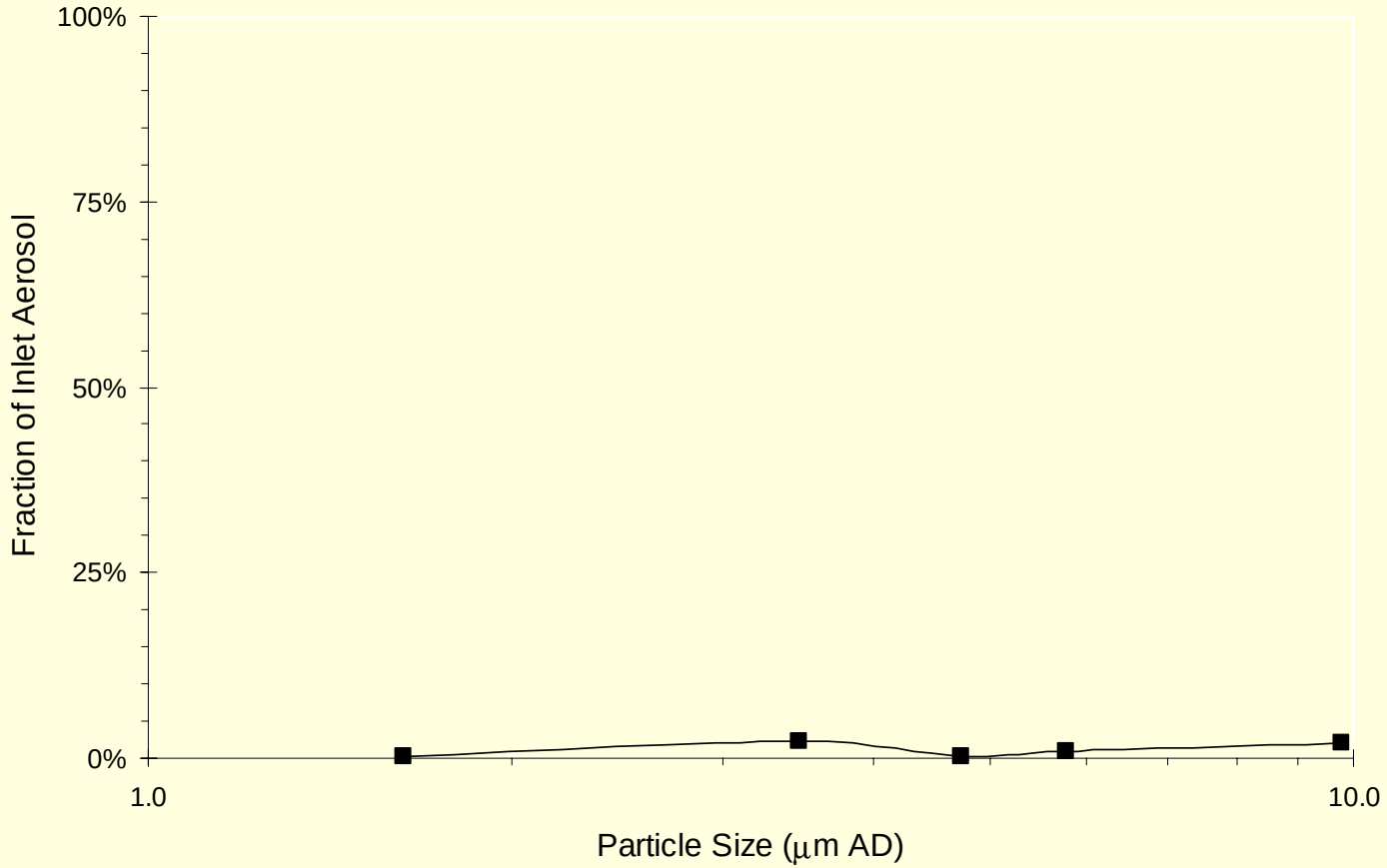
Wall Losses on Critical Zone of CSVI



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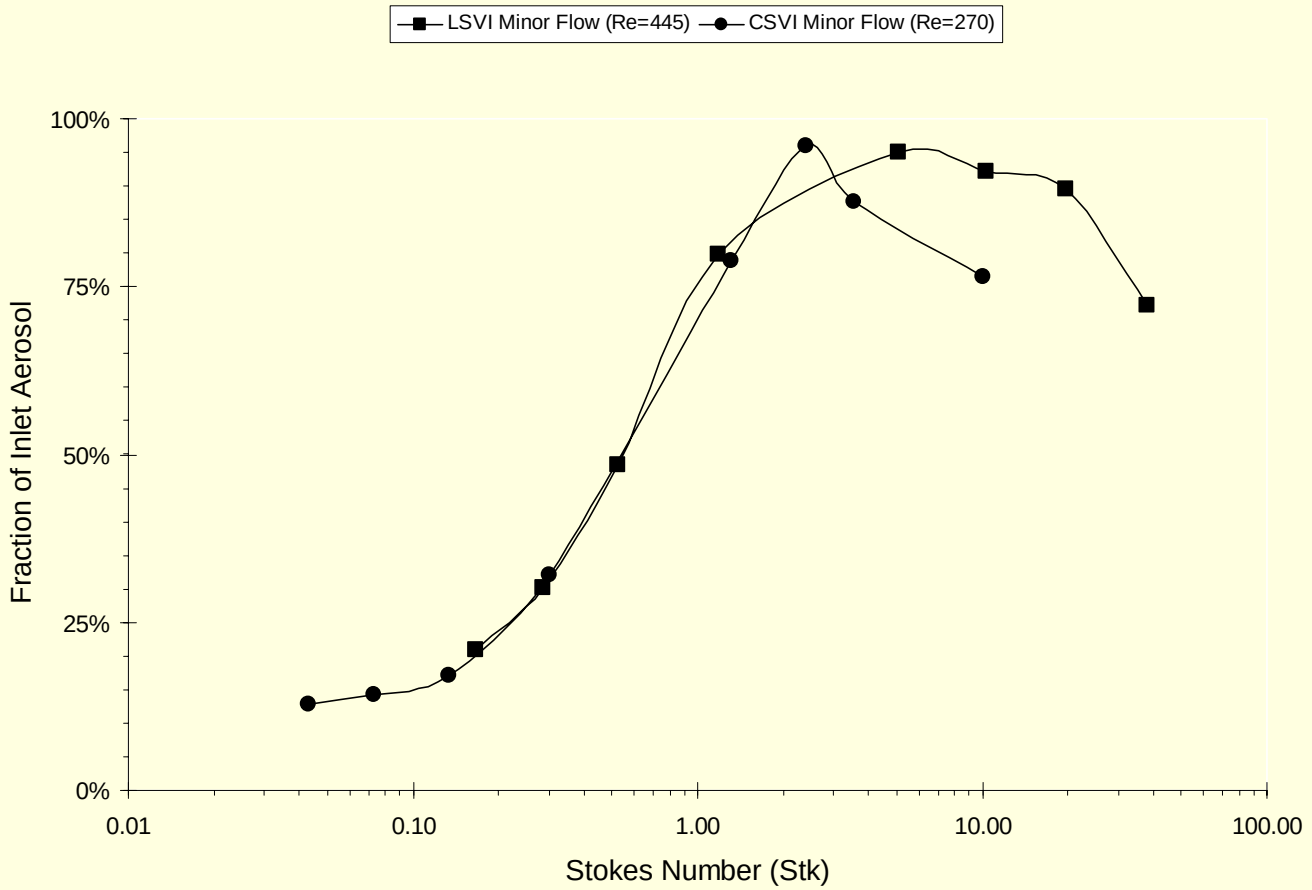
LSVI and CSVI Minor Flow Collection Efficiency on Stokes Number Basis



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Research Plans

- **Construct Single-Stage LSVI Concentrator System**
  - Eight LSVI units operating in parallel for 300 L/min total sampling rate.
  - Design flow control instrumentation.
  - Test with monodisperse aerosols: PSL (non-viable), single-spore BG, monodisperse BG clusters.

- **Identify and Eliminate Acoustic Resonance in LSVI units**
  - Determine resonance source (Helmholtz, standing-wave).
  - Tapered major flow path.
  - Materials maximizing acoustic absorption.

- **Construct new CSVI unit**
  - 0.012” Acceleration Slot Width.
  - Incorporate resonance elimination features.
  - Add additional stages.
  - Test with monodisperse aerosols: PSL (non-viable), single-spore BG, monodisperse BG clusters.